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THERMODYNAMICS AND RELATIVITY. II

By PROFESSOR RICHARD C. TOLMAN

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(5) CONSEQUENCES OF RELATIVISTIC THERMODYNAMICS

To complete our discussion, we must now consider the possible consequences of relativistic thermodynamics. The technical modifications in thermodynamic theory needed to secure its extension to relativity may have seemed too trivial and obvious to warrant the expectation that these consequences could be very novel or interesting. Nevertheless, the actual effect of replacing classical ideas as to the nature of space and time by relativistic ideas is so fundamental as to lead to important differences between the results of classical and relativistic thermodynamics. Three examples may now be given to illustrate both the essential novelty and the inherent rationality of the consequences of relativistic thermodynamics.

(*a*) *Temperature Gradient in Gravitational Field.* In the classical thermodynamics we have become accustomed to the conclusion that a system which is in thermal equilibrium will necessarily have uniform temperature throughout. As a result of relativistic thermodynamics, however, it is found that this conclusion must be modified in the presence of appreciable gravitational fields. Thus if we consider a spherical distribution of material held together in static equilibrium by its own gravitational forces, corresponding to the line element,

$$ds^2 = -e^{\mu}(dr^2 + r^2 d\theta^2 + r^2 \sin^2\theta\, d\phi^2) + e^{\nu} dt^2 \qquad (23)$$

where μ and ν are functions of r alone, it can be shown[8] that the condition for thermal equilibrium is given by

$$\frac{d \log T_0}{dr} = -\frac{1}{2}\frac{d\nu}{dr} \qquad (24)$$

where T_0 the proper temperature as measured by a local observer decreases as we go outward instead of remaining constant. And for the more general static case of a system, not necessarily having spherical

[8] Tolman, *Phys. Rev.*, 35: 906, 1930.

symmetry, but corresponding to the more general line element

$$ds^2 = g_{ij}\, dx^i dx^j + g_{44} dt^2 \qquad (i, j = 1, 2, 3) \qquad (25)$$

where g_{ij} and g_{44} are independent of t, it has been shown by Professor Ehrenfest and myself[9] that the condition for thermal equilibrium would be given by a constant value throughout the system for the product

$$T_o \sqrt{g_{44}} = \text{const} \qquad (26)$$

rather than for the proper temperature T_o itself.

From an observational point of view, this new conclusion may not be very important, since the change in temperature with position would only be

$$\frac{d \log T}{dr} = 10^{-17}\ \text{cm}^{-1} \qquad (27)$$

in a gravitational field having the intensity of that at the earth's surface. From a theoretical point of view it is of interest, however, in leading to a modification of one of the most cherished results of the classical thermodynamics.

It should be emphasized, nevertheless, that this modification is entirely reasonable from the point of view of relativity. In accordance with that theory all forms of energy have mass and weight, and it is hence indeed not surprising that a temperature gradient is necessary to prevent the flow of heat from regions of higher to those of lower gravitational potential when thermal equilibrium has been reached. Furthermore, since the pressure of black-body radiation in equilibrium with a thermal system would evidently have to increase as we go to lower gravitational levels, in order to support the weight of radiation above, we can also see from purely mechanical considerations that temperature must increase with depth.

(*b*) *Possibility for Reversible Processes at a Finite Rate.* To turn to a second example, we have long been accustomed to believe as a result of the classical theory that *reversible* thermodynamic processes taking place at a *finite rate* could never occur in nature, since a finite rate of change would make it impossible to achieve that maximum efficiency which would permit a restoration both of the system and its surroundings to their original states.

To illustrate this we may consider a fluid contained in a cylinder with non-conducting walls and provided with a piston as shown in Fig. 1. The *reversible* expansion of this fluid with the piston moving out at a *finite rate* would evidently be impossible, in the first place since there would be friction between the piston and the walls, and in the second place since the fluid in flowing in behind the moving piston would not be able to maintain as high a pressure and hence do as much external work as at an infinitesimal rate of expansion. It has hence been concluded in the past that the reversible expansion of a fluid at a finite rate would under all circumstances be impossible.

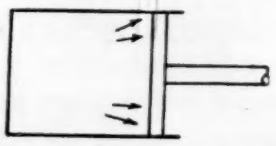

FIG. 1. Classical cylinder

[9] Tolman and Ehrenfest, *Phys. Rev.*, 36: 1791, 1930.

In relativistic thermodynamics, nevertheless, this situation is altered in an important manner by new possibilities for changes to take place in the proper volume of an element of fluid, because of changes in the gravitational potentials which were neglected in the older theory. To illustrate this, Fig. 2 attempts

FIG. 2. Relativistic non-static universe

to give a symbolic two-dimensional representation of the space-like coordinates, corresponding to the line element

$$ds^2 = -\frac{e^{g(t)}}{\left[1 + \frac{r^2}{4R^2}\right]^2} (dr^2 + r^2\, d\theta^2 + r^2 \sin\theta\, d\phi^2) + dt^2 \qquad (28)$$

which characterizes the homogeneous distribution of fluid, that we usually call a non-static model of the universe. These coordinates are so selected that any element of fluid lying in a given coordinate range $\delta r\ \delta\theta\ \delta\phi$ will remain permanently therein. The proper volume of such an element of the fluid as measured by a local observer will then be

$$\delta V_o = \frac{e^{\frac{3}{2}g(t)}}{\left[1 + \frac{r^2}{4R^2}\right]^3} r^2 \sin\theta\, \delta r\, \delta\theta\, \delta\phi \qquad (29)$$

and this will change with the time t at a finite rate on account of the occurrence of the function g(t) in the gravitational potentials and hence also in the expression for proper volume.

These changes in proper volume take place, however, in the first place quite obviously without any friction of moving parts, and in the second place with a perfect balance between internal and external pressures owing to the uniformity of conditions throughout the fluid. Thus the two sources of irreversibility in the previous classical illustration are completely eliminated. Furthermore, there can be no irreversible

heat flow in the model under consideration, again owing to the uniform conditions throughout the fluid and the possibility of irreversible processes within each element of the fluid can be eliminated by the choice of a sufficiently simple substance. As a consequence it has proved possible to construct conceptual models of this kind[10] which can expand or contract at a finite rate, and nevertheless satisfy the relativistic condition for reversibility by maintaining the sign of equality instead of inequality in the simple expression

$$\frac{d}{dt}(\phi_o \, \delta V_o) \geqq 0 \qquad (30)$$

which results from the application of the general form of the relativistic second law (19) to the present case.

This possibility for reversible thermodynamic processes taking place at a finite rate seems very strange from the point of view of the classical thermodynamics. Nevertheless, from the relativistic point of view the result seems both rational and, indeed, perhaps inevitable, when we recall that the principles of *relativistic mechanics* alone, without bothering about thermodynamics, have been found sufficient to show[11] the possibility of constructing models of the kind in question, which—when filled with such simple fluids as a perfect monatomic gas or black-body radiation—would expand at a finite rate to an upper limit and then precisely retrace their steps to their original density, pressure and temperature.

(*c*) *Possibility for Irreversible Processes without Reaching a Final State of Maximum Entropy.* As a final example of the differences between classical and relativistic thermodynamics, let us now turn to the classical conclusion that the ultimate result of irreversible processes taking place in a system having no interaction with its surroundings would necessarily be a state of maximum entropy where further change would be impossible.

To illustrate the classical reasons for belief in this principle, let us consider a simple homogeneous system consisting of a gas of uniform pressure, temperature, and composition throughout. The state of such a system can be specified by its energy E, volume v, and the number of mols N_1, N_2, etc., of the different chemical substances which it contains, and in accordance with a fundamental expression, provided by the work of Gibbs himself,[12] its entropy can then be determined with the help of the general equation

$$dS = \frac{dE}{T} + \frac{p}{T}dv + \left(\frac{\partial S}{\partial N_1}\right) dN_1 + \left(\frac{\partial S}{\partial N_2}\right) dN_2 + \ldots \qquad (31)$$

[10] Tolman, *Phys. Rev.*, 37: 1639, 1931; *ibid.*, 38: 797, 1931.

[11] Einstein, Berl. Ber. (1931) p. 235; Tolman, *Phys. Rev.*, 38: 1758, 1931.

[12] Allowing for the difference in notation and form, equation (31) is equivalent to the fundamental equation (12) given in the "Collected Works of Gibbs." Vol. I, p. 63. Longmans, Green and Company, 1928.

In applying this expression, however, to the special case of a system having no interaction with its surroundings, it was necessary in the classical thermodynamics to take the energy change dE equal to zero to agree with the classical principle of energy conservation. It was also necessary, for a system having no interaction with its surroundings, to take either the volume-change dv equal to zero or the pressure p itself equal to zero to prevent the performance of work on the surroundings. In both cases the only chance for entropy increase and hence for change would then lie in the readjustment of chemical composition. At constant energy and volume, moreover, this would have to cease when the entropy reached the maximum possible value compatible with the fixed value of energy and volume; while at constant energy and zero pressure the gas would be infinitely dilute and a final state of maximum entropy would be reached when all the molecules of gas had disassociated into their atoms.

In the relativistic treatment of this problem, nevertheless, the application of relativistic mechanics alone is sufficient to show a very different state of affairs. In the relativistic treatment, the analogue of the preceding homogeneous isolated system will evidently be a non-static model of the universe, since the line element for these models corresponds to a completely homogeneous distribution of fluid with no interaction with anything outside the system itself. By the application of relativistic mechanics, however, it has been shown by the work of Professor Ward and myself,[13] that there is a great class of such models, obtained by taking the cosmological constant Λ equal to zero or less, which could apparently undergo a continued succession of expansions and contractions without ever coming to rest. To be sure, the equations that we now have available for our highly idealized models are only sufficient to describe the expansion of the models to their upper limit and return, and not sufficient to describe their passage through the exceptional point at their lower limit of volume. Nevertheless, on physical grounds we must be inclined to assume that contraction to the lower limit of volume would be followed by renewed expansion.

It is to be specially noted now, however, that our conclusion as to the possibility of such behavior is based solely on mechanical equations alone and is quite independent of assumptions as to the reversibility or irreversibility of any thermodynamic processes that may take place in the fluid, although in the case of irreversible processes it can be shown that successive expansions have a tendency to go to larger and larger volumes before returning. The possibility thus

[13] Tolman, *Phys. Rev.*, 39: 320, 1932; Tolman and Ward, *ibid.*, 39: 835, 1932.

provided for an unending succession of irreversible expansions and contractions seems very strange from the point of view of classical thermodynamics, but can nevertheless be shown to be reasonable from the point of view of relativistic thermodynamics.

The application of the relativistic second law to these non-static models leads to the general result

$$\frac{d}{dt_o}(\phi_o \delta V_o) \geqq 0 \qquad (32)$$

which states that the proper entropy of each element of the fluid as measured by a local observer can only remain constant or increase with local time. With a fluid of composition simple enough to eliminate the possibility for changes other than in density, we obtain the conditions necessary for constant entropy, and are led to the reversible expansions and contractions at a finite rate previously considered. With a slightly more complicated fluid, such as a gas which tends to disassociate as the density is lowered, we can obtain the irreversible increases in entropy in which we are now interested, since the composition of the fluid will then lag behind the changes in volume, and the processes of disassociation and recombination will always take place in the direction of an equilibrium which has not been attained.

From a classical point of view, such a continuous irreversible increase in entropy in an isolated system which undergoes a never-ending succession of expansions and recontractions to an earlier volume might seem impossible, since the energy of the isolated system would have to remain constant, and with a given value of energy and volume there would be a definite, maximum possible value of entropy.

From the relativistic point of view, nevertheless, it is easy to see that this continued increase in entropy could be made possible by the failure in relativistic mechanics of the ordinary principle of energy conservation. Indeed the application of relativistic mechanics to the models in question leads to the result

$$\frac{d}{dt_o}(\rho_{oo} \delta V_o) + p_o \frac{d}{dt_o}(\delta V_o) = 0 \qquad (33)$$

which shows that the proper energy $(\rho_{oo} \delta V_o)$ of each element of fluid in the model will decrease as the model expands and increase as it contracts, and since the general effect of irreversibility would be to give higher pressures during compression than during the preceding expansion, we are thus provided with the needed mechanism for a gradual increase in proper energy and hence also in the proper entropy of the elements of fluid.

The difference between the classical and relativistic points of view can also be illustrated in a somewhat different manner, if we return to the classical cylinder and relativistic model of the universe given by Figs. 1 and 2, and consider a continued succession of expansions and contractions, in both cases providing for irreversibility by again introducing for example a gas which tends to disassociate when the pressure is lowered.

The classical man who is engaged in moving the piston of his cylinder successively in and out reports that the entropy inside the cylinder is all the time getting greater and greater, because the gas can not disassociate fast enough on the way out nor recombine fast enough on the way in to maintain equilibrium. He also reports, however, that the energy inside his cylinder—which is now no longer an isolated system—is also getting greater and greater, since the pressure has a tendency to be too high to correspond to equilibrium on compression and too low on expansion, so that he does more work on the way in than he gets back on the way out. He then finally remarks that this continued increase in energy indeed provides in the case of this non-isolated system an opportunity for the entropy to go on increasing forever, but that he personally is getting very tired of the silly experiment, and is going to have to stop:—not now because the irreversible processes will ever lead to an unsurpassable maximum of entropy but because he actually won't have the necessary energy to push in the piston one time more.

How different the remarks of the relativistic man as he sits calmly by and—in his mind's eye—watches his conceptual model expand and contract. "Yes," he says, "I notice that the proper entropy of each element of fluid is all the time increasing owing to successive processes of disassociation and recombination under conditions that do not correspond to equilibrium." "I do not worry, however, since I also notice that the proper energy of each element of fluid is also increased after a succession of expansions and contractions sufficiently to allow for this increase in entropy, and I know that the principles of relativistic mechanics not only permit such increases in proper energy, but indicate—without reference to reversibility or irreversibility—the continued succession of expansions and contractions that I observe."

This completes the discussion of examples illustrating the kind of conclusions that we may expect from the extension of thermodynamics to general relativity.

(6) Conclusion

Much remains to be done in the further application and development of relativistic thermodynamics. The application to systems in which heat flow is taking place from one portion of the fluid to another has not yet been undertaken and might lead to interesting results. It could be of special importance when we

have made more progress in the treatment of non-homogeneous models of the universe which may well be necessary for a better understanding of the actual universe. The development of relativistic thermodynamics to include an appropriate treatment of fluctuations might also be attempted with the help of the statistical methods introduced by Gibbs himself. The effect of fluctuations on the behavior of cosmological models might be specially important at certain stages of their history.

In trying to estimate the significance of the applications of relativistic thermodynamics that have already been made, we must not misjudge the nature of the two applications to cosmological models that were described in the foregoing. It should be emphasized that the homogeneous cosmological models which we now consider are not only very highly simplified and idealized, but at best are constructed to agree throughout their entire extent with that small sample of the actual universe which lies within the range of some 10^8 light years. Furthermore, it must be remembered that among the different possible kinds of homogeneous cosmological model, there is a class which would expand never to return as well as the class that could undergo an unending succession of expansions and contractions; and we do not now have sufficient data so that we could assign the actual universe to either class. Hence we must be very careful, in extrapolating to the actual universe any conclusions that we may draw as to the behavior of our conceptual models.

The dangers of long-range extrapolation were specially emphasized to you by Professor Bridgman in his beautiful Gibbs memorial lecture of last year, and these dangers, as we see, are specially present in cosmological speculations, based on the observation of a small fragment of the total universe for an inappreciable time span. Nevertheless, it certainly seems significant that conceptual models of the universe can be constructed, which are permitted by the principles of relativistic thermodynamics to exhibit behavior in serious conflict with the classical conclusions, that reversible processes could never take place at a finite rate, and that the end result of irreversible processes would necessarily be a stationary condition of maximum entropy. Hence at the very least it would now seem desirable to extrapolate to a cautious position, in which we no longer dogmatically assert that the principles of thermodynamics necessarily require a universe created at a finite time in the past and fated for stagnation and death in the future. Indeed, the chief duty and glory of theoretical science is certainly, not merely to describe in complicated language those facts that are already known, but to extrapolate—as cautiously and wisely as may be—into regions yet unexplored but pregnant with human interest.

ACTIVE IRON

By Dr. OSKAR BAUDISCH

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IN the year 1806 the Bergrat Johann Georg Lenz named a natural iron oxide hydrate "goethite," in honor of the celebrated naturalist and poet, Johann Wolfgang von Goethe. This mineral had already been known in the literature previously under the name ruby mica (Rubinglimmer).[1] Although comparatively rare, it is found in good crystalline form in Siegen, in Westphalia. The splendid crystals, one to two millimeters long, indeed resemble rubies in their beautiful color and luster. The crystals or powder made from them are non-magnetic, but if one dehydrates the powder by heating it a magnetic iron oxide, Fe_2O_3, is obtained. This interesting observation was described as early as 1838 in the book "Grundzüge der Mineralogie" by Franz von Kobel (published in Nürnberg in 1838). The names ruby mica and goethite are used interchangeably for this macro-crystalline brown iron ore in the "Manual of Mineralogy" by Robert Allan (Edinburgh, 1834). It is seen, therefore, that historically the names ruby mica and goethite properly apply to the natural iron oxide hydrate which becomes magnetic on heating.

In the year 1848, Plücker made a magnetic study of the natural and artificial iron oxides and oxide hydrates, and observed that an iron oxide hydrate prepared in a certain way gave a magnetic iron oxide on dehydration. He found it almost a hundred times stronger magnetically than the original hydrate from which it was prepared, and remarked that the powdered material could be picked up by even a small horseshoe magnet. Robbins mentioned a magnetic iron oxide in *Chemical News* in the year 1859.

Malaguti in 1863 (*Compte Rendus*) published more exact chemical and physical data on the properties of magnetic iron oxide. He obtained the oxide in various ways, as, for example, by explosion of magnetite with potassium chlorate and by heating ferrous salts of organic acids in the air. In France the magnetic iron oxide is also known under the name Malaguti-oxide.

[1] J. F. L. Hausman, "Handbuch der Mineralogie," Göttingen, 1813.

The fact that this magnetic iron oxide contained iron only in its completely oxidized state (ferric), was definitely established by Hilpert in 1909. Until this time all samples had contained varying amounts of incompletely oxidized iron (ferrous).

To turn again to the iron oxide hydrates, it must be noted that our view-points on these important iron compounds, which occur so abundantly in nature, have been fundamentally changed. Formerly on a basis of chemical analysis and superficial characterization, the natural iron oxide hydrates were classified as to water content. Thus, iron oxides combined with 3, 2, 1½, 1, ¾ and ½ molecules of water were classed as separate species. These distinctions did not recognize the fact that part of the total water present is chemically linked and part only absorbed. Consequently, the majority of the older chemical formulas assigned to iron oxide hydrates are meaningless.

More exact studies, in particular x-ray analyses, have proved that there is only one definite chemical combination between iron oxide and water, namely, the monohydrate, $Fe_2O_3 \cdot H_2O$. This is known to exist in two different modifications, both of which exist in nature and may be prepared synthetically. Since the oxides prepared by dehydration of the two monohydrates are genetically related to the natural dimorphous aluminum oxides, diaspore and bauxite, according to a proposal of Haber (*Naturwissenschaften,* 1925) they were named α and γ hydrates and oxides. This designation has been adopted not only by chemists and physicists but by mineralogists as well.

There are two common differences between the α and γ hydrates. Each has a distinct x-ray spectrum. Also they may be more easily distinguished by their magnetic properties. The α hydrates on dehydration yield a non-magnetic α oxide (hematite), while the γ hydrates yield a strongly magnetic (ferromagnetic) γ oxide. Since goethite, as we have seen, becomes ferromagnetic on dehydration it belongs to the γ hydrate class.

The various natural iron oxide hydrates formerly mentioned are merely micro-crystalline aggregates of α $Fe_2O_3 \cdot H_2O$ (Böhm, 1928; Albrecht, 1929). The differences depend partly on a chemical reaction (polymerization) of the molecules, and partly on the difference in the arrangement, form and size of the crystallites (clusters of sub-microscopic crystals). The different shades of color depend mainly on the particle size.

For the more detailed study of the structure (fine and hyper-fine structure) which remains to be carried out, it is necessary first of all to have pure materials. It is important to prepare iron oxide hydrates and iron oxides which are free from electrolytes, since such impurities may greatly influence the magnetic and surface properties. This we have succeeded in doing, through the use of organic bases, for example, pyridine and aniline. The purest obtainable iron, that prepared from iron pentacarbonyl, serves as starting material. It is dissolved in hydrochloric acid and autoxidized in the presence of pyridine to a very pure γ iron oxide hydrate, with the study of which we are now concerned. This γ hydrate gives on dehydration a ferromagnetic ferric oxide which is free from all impurities of electrolytes.

There now remains only to report briefly of the progress that has been made with γ oxide since the work of Hilpert, and how our study in this field has brought us to designate the concept "active iron."

The fundamental discovery which led to the introduction of the concept "active iron" into biology was that of Welo and Baudisch[2] concerning the interesting and peculiar behavior of ferromagnetic ferric oxide. We found that the lattice of ferromagnetic ferric oxide, Fe_2O_3, is cubic, whereas hematite, Fe_2O_3, is rhombohedral, as was already known. The paramagnetic modification corresponding to hematite is stable, while the ferromagnetic modification is unstable and can pass over, with loss of energy and loss of ferromagnetism, into the stable form. The surprising observation that magnetite retains its spinel crystal structure on oxidation and first passes to the rhombohedral hematite structure on strong heating led us to designate the ferromagnetic gamma oxide as "active" in contrast to the inactive form corresponding to hematite. The strikingly different physical and physico-chemical behaviors of these chemically identical iron oxides led us to compare their biological actions. The experiments of Webster and Baudisch showed, in fact, that the two oxides had different biological effects. The designation "active iron" therefore assumed biological significance.

Since, in the medical literature, the term "active iron" has often been completely distorted and confused in relation to and in comparison with the sense in which we use it, it seems necessary to include a further discussion of the development of the problem. The original identification of the two forms of ferric oxide (alpha and gamma), became, one might say, only an introduction to further study and further knowledge of the topochemistry and the magnetic properties of iron oxides. The designations "active" and "inactive" had, later, to be expanded and developed.

It has been mentioned that by x-ray analysis one can determine only the type of arrangement, while by magnetic measurements one can at least detect

[2] SCIENCE, 62: 1605, 311–312. 1925.

finer structural anomalies and consequent surface irregularities. We therefore made detailed magnetic studies of magnetite and several ferromagnetic iron oxides prepared in different ways. This was done, as is usual in the study of ferromagnetic materials, by taking the magnetization curves for increasing and decreasing magnetizing fields; that is, we determined the hysteresis loops. The four constants characteristic of ferromagnetic materials may be obtained from these curves. They are: the permeability (simply related to susceptibility), which is a measure of the magnetization; the hysteresis loss, which is a measure of the resistance to orientation of the elementary magnets and hence appears as a transformation of electromagnetic energy into heat; the remanence, which is the residual magnetization after the field is removed, since orientation, when once attained, may persist in varying degree; and finally, the coercive force, which is the field that must be applied in the opposite direction to demagnetize the substance. Both remanence and coercive force are secondary features of the hysteresis phenomenon. If the hysteresis loss is large, both the remanence and the coercive force are large. For example, in steel hysteresis loss, remanence and coercive force are large, while in soft iron all three of these quantities are relatively small.

The result of these studies was that while the several oxides differed somewhat as to permeability, they differed enormously as to the constants associated with hysteresis. But after the several differently prepared oxides had been annealed at high temperatures they gave nearly the same values for the hysteresis loss, remanence and coercive force. It is this fact which is the basis for our conclusion that it is the crystal quality (lattice perfection and absence of atomic deformation) which is markedly affected by changing the method of preparation. The magnetic investigation, therefore, gave us a means of tracing the finer structural features which occur in regions of too small dimensions or are for other reasons not accessible to x-ray analysis. In other words, while we can establish the fine structure of ferromagnetic iron oxides by the x-ray, it becomes possible by magnetic analysis to establish the existence of a still finer one—a hyperfine structure.

To these exact physical methods of investigation the biological methods joined themselves naturally and it was found that the latter were not less but rather more sensitive than the magnetic methods to hyperfine structural differences. By combination of these methods one can gain an insight into biological phenomena that would otherwise be quite impossible.

Our investigations, as they have been briefly described in the foregoing, have given rise to a whole array of researches in the field of the metal oxides, especially those of iron. Chemists, physicists, engineers, mineralogists, geologists, pharmacologists and medical men have repeated the experiments and supplemented them in various directions, according to their particular fields of interest.

SCIENTIFIC EVENTS

THE JUNIOR SCIENCE CLUBS OF THE AMERICAN INSTITUTE

THE Junior Science Clubs of the American Institute were the guests, on the morning of March 25, of the Museum of Science and Industry and the American Museum of Natural History.

Museum Day was planned by the American Institute as a new departure in its program of science educational projects for children. Recently the institute, a century old organization, has associated hundreds of science clubs made up of young people all over the city into its new branch, the Junior Science Clubs. The members of these clubs represent some seven or eight thousand children, all under eighteen years of age.

The meeting at the Museum of Science and Industry was open to all member Physical Science Clubs. The group was divided into two sections, one going directly to the main exhibit hall and one to the museum theater. In the main exhibit hall, Robert P. Shaw, of the Museum of Science and Industry, spoke on "The Story of Electricity." The hall was darkened and a spotlight was thrown on the various exhibits as they illustrated Mr. Shaw's talk. In the museum theater, the second group was shown the following series of science motion pictures: "The Romance of Power"; "Dynamic America"; "A. B. C. of Electricity," and "Finding His Voice." The groups then changed places and the program was repeated.

To the American Museum of Natural History meeting members of the Biological Science Clubs were invited.

At the meeting at the museum Paul B. Mann, chairman of the department of biology of Evander Childs High School, spoke on "The Museum's Part in Exploration," illustrated with motion pictures taken by Roy Chapman Andrews.

The group was then broken up into five sections, each of which visited one of the various museum trails. Members of the museum's staff were stationed in the different halls, where they gave short talks on the contents of each. The children then, under the guidance

of these staff members, spent the rest of the morning inspecting the Darwin Hall, Insect Hall, Mammal Hall, Bird Hall and Fish Hall.

THE SIXTH ANNUAL SUMMER SYMPOSIUM IN THEORETICAL PHYSICS AT THE UNIVERSITY OF MICHIGAN

IN the summer of 1923, the University of Michigan invited Professor Karl T. Compton of Princeton University and Professor F. A. Saunders of Harvard University to give special lectures during the summer session. These lectures initiated a policy which has been maintained ever since. For the first five years the subjects covered by the lecturers were primarily in the field of experimental physics, but beginning with the session of 1928, a symposium in theoretical physics was inaugurated, and since that date the visiting lecturers have treated theoretical subjects exclusively. An examination of the list of lecturers discloses the fact that many of the foremost physicists of America and Europe have appeared on these summer programs. Particularly in recent years these meetings have attracted not only advanced students but also members of other university and college faculties, and research physicists from governmental and industrial laboratories. The summer is apparently the only time that such men can attend, and the course of eight weeks is sufficiently long to give a very adequate treatment either of an introductory course in modern theoretical physics or of a very advanced one covering perhaps material receiving its first public presentation. In addition to the regular lecture courses there are numerous informal meetings of groups limited to those interested in special problems.

The sixth symposium will be held between the dates June 26 and August 18. In the first or second week of this period Professor Niels Bohr of Copenhagen will give several lectures on "The Foundations of Atomic Mechanics." Professor Enrico Fermi of Rome will lecture throughout the eight weeks of the session on "The Structure of the Atomic Nucleus." Following Professor Bohr's lectures Professor J. H. Van Vleck of Wisconsin will lecture for four weeks on "The Recent Developments in the Theory of Magnetism." Professor G. E. Uhlenbeck of Michigan will give a course on "Quantum Mechanics" and Professor D. M. Dennison of Michigan a course on "The Theory of Band Spectra." Both of these last courses will be given throughout the summer. The informal seminars which meet several times weekly will be under the general supervision of Professors Fermi and Van Vleck. Holders of doctors degrees may attend all lectures, courses and seminars as guests of the university.

In addition to the symposium lectures the department of physics offers its regular advanced courses. Facilities for experimental research are available, particularly in spectroscopy in the fields of x-rays, ultra violet, visible, near and far infra-red, in sound, in electronics and in vacuum tube phenomena.

CONFERENCE ON RECENT DEVELOPMENTS IN CHEMISTRY AT THE JOHNS HOPKINS UNIVERSITY

THE Johns Hopkins University will this summer conduct a second conference on recent developments in chemistry in conjunction with the regular summer session at the institution.

The conference will be divided into five consecutive sessions of one week each. Each week will be devoted to one phase of chemical progress, and will include lectures by men known in that particular field.

"Organic Chemistry Related to Medicine" will be the subject of discussion during the week of June 26, and speakers from the Johns Hopkins School of Medicine and from outside institutions will present various phases of the work. E. Emmet Reid and G. H. Corwin will have charge of the week's program. On June 26, Hugh Young, Justina Hill, Fitzgerald Dunning, Edwin C. White and W. C. Harden will deal with the general subject of "Antiseptics." On June 27, "Oxidation and Reduction" will be discussed by E. Emmet Reid, Leslie Hellerman and G. H. Corwin.

Gordon M. Dean and Hans Jensen will be the speakers on June 28, presenting phases of the topic, "Insulin and Proteins." A sound film, "Some Biochemical, Pharmacological and Medical Experiences as Told to Chemists," by Dr. John J. Abel, will be shown in the evening of that day. On June 29 Joseph C. Bloodgood will preside over a program devoted to "Chemistry and Physics in Cancer." The speakers will include Dr. Bloodgood, Charles F. Geschickter, E. A. Peterson, Dudley Jackson, Curtis Burnam, M. A. Tuve, Carl Voegtlin, Warren H. Lewis, Margaret Lewis and George Otto Gey. Motion pictures related to the subject of cancer will be presented in the evening. June 30 will be devoted to "Chemotherapy," aspects of which will be discussed by Hugh Young, Justina Hill and David I. Macht.

During the week of July 3, Joseph E. Mayer will preside over a program devoted to "Physical Treatment of Molecular Binding." The speakers for the week, in the order in which they will present their discusisons, are Dr. Mayer, Maurice L. Huggins, Hugh M. Smallwood, Henry Eyring and Saul Dushman. "X-rays and Structure of Matter" will be the general topic for the week of July 10. Emil Ott will preside, and speakers for the week will include Ralph W. G. Wyckoff, Maurice L. Huggins and Dr. Ott. For the week of July 17, a topic of especial

interest to physicists has been selected. "The Application of Optical Methods and Instruments to Chemical Research" will be discussed, A. Herman Pfund presiding over the week's program. The speakers will be Dr. Pfund, George F. A. Stutz, H. E. Merwin and Ralph H. Muller.

The final week will be devoted to the subject of "Catalysis." J. C. W. Frazer will be chairman of the program for the week of July 24, and the speakers for the conference will include Paul Hugh Emmett, Dr. Frazer, Arthur F. Benton, J. A. Becker and Herbert G. Tanner.

Those interested in the conferences may register for the full five weeks, or for any part of the program that attracts them. Cottages on the shore of the Chesapeake Bay, within commuting distance of the university, are available for those who wish to combine a summer vacation with scientific study and discussion.

IN HONOR OF DR. ELIHU THOMSON

ACCORDING to the final plans for the dinner held at the Massachusetts Institute of Technology on March 29, leaders in science, engineering and education paid tribute to Dr. Elihu Thomson, dean of electrical engineers and inventor, on his eightieth birthday.

A correspondent writes: "Within the span of four score years Dr. Thomson, a pioneer in electrical science, has witnessed and played an important part in the development of the country's great electrical industry. He is the last of the magnificent 'big four,' Thomas A. Edison, Charles F. Brush and James J. Wood. Three of them gave the people electric lighting systems, Edison invented the incandescent lamp. To-day Dr. Thomson is the 'last of the first,' with more than seven hundred United States patents to his credit. From 1920 to 1922 Dr. Thomson was acting president of the Massachusetts Institute of Technology. He is a life member of its corporation and a non-resident professor of applied electricity."

On the afternoon of Dr. Thomson's birthday there was a conference at which brief lectures on the historical development of the applications of electricity, modern theories and the present trends of research were presented. According to the program, President Karl T. Compton, of the Massachusetts Institute of Technology, discussed the historical aspects of electricity with particular reference to Dr. Thomson's achievements in this field. Dr. John C. Slater, head of the institute's department of physics, discussed modern theories of electricity, and Dr. K. K. Darrow, research physicist at the Bell Telephone Laboratories, spoke on the trends of modern research.

As part of this celebration, many models and some of the originals of Dr. Thomson's most significant inventions were on exhibition. This exhibition was open to guests on Wednesday, continuing for the public from Thursday to Sunday, from 2 to 5 P. M. The models included the frictional electrical machine made from a discarded wine bottle by Dr. Thomson when he was eleven years old, and a dynamo invented in 1878, which has all the essentials of the great modern generators. Many early types of the arc lamps designed by Dr. Thomson and his colleague, Professor E. J. Houston, are shown. One of the most significant exhibits was the Thomson recording wattmeter, forerunner of the 30,000,000 meters now installed in homes, factories and stores to record the amount of energy consumed. There were shown early types of lightning arresters, as well as Dr. Thomson's first electrical resistance welding transformer, a method which is now universally used in almost every branch of manufacturing.

It was expected that President Karl T. Compton would preside at the dinner, at which Governor Joseph B. Ely, of Massachusetts, would voice the tribute of the people of Massachusetts to Dr. Thomson. George B. Cortelyou, president of the Consolidated Gas Company of New York, was expected to speak for the electrical industries and Dr. Harry P. Charlesworth, president of the American Institute of Electrical Engineers, in the name of the engineering societies, to pay honor to the inventor. The tribute of educational institutions, many of which had bestowed upon Dr. Thomson their highest academic honors, was to be given by Dr. Vannevar Bush, vice-president of the institute and dean of engineering. Other speakers announced were Dr. Harvey Cushing, of Harvard University, who represented professions other than engineering, and Mr. E. W. Rice, Jr., honorary chairman of the board of the General Electric Company, its former president, and one of Dr. Thomson's earliest associates in the electrical industry in Lynn, for his friends and colleagues.

SCIENTIFIC NOTES AND NEWS

DR. WILLIAM H. WELCH, whose eighty-third birthday occurred on April 8, has been confined to the Brady Clinic of the Johns Hopkins Hospital since February 1. It is announced that there is a slow improvement in his condition.

DR. THEOBALD SMITH, of the department of animal pathology, Rockefeller Institute for Medical Research, Princeton, New Jersey, will deliver the Thayer Lectures at the Johns Hopkins Medical School on April 5, 6 and 7.

PROFESSOR ARTHUR H. COMPTON, of the University of Chicago, will direct courses in "Electricity and Magnetism" and on "X-Rays and Electrons" during the summer session of Columbia University.

AT a dinner in celebration of the seventy-fifth anniversary of the Pathological Society of Philadelphia on March 9, honorary membership was conferred on Drs. Harvey Cushing and Frank B. Mallory, of the Harvard Medical School; on Dr. James Ewing, of Memorial Hospital, New York, and Dr. Karl Landsteiner, of the Rockefeller Institute. Dr. Fielding H. Garrison, of the Johns Hopkins University, and Dr. David Riesman, of the University of Pennsylvania, were the principal speakers.

DR. FRITZ VON WETTSTEIN, professor of botany at Munich, has been elected a member of the Bavarian Academy of Sciences. Corresponding members have been elected as follows: Dr. Franz Meyer, professor of mathematics at Königsberg; Dr. Kurt Hensel, professor of mathematics at Marburg; Dr. Paul Guthnick, professor of astronomy at Berlin, and Professor Hans Ludendorff, director of the Astrophysical Observatory at Potsdam.

THE Royal Aeronautical Society has awarded its gold medal to Sir Richard Glazebrook, from 1899 to 1919 director of the British National Physical Laboratory. This medal has been awarded six times previously: to the Wright brothers, Octave Chanute, Professor Bryan, E. T. Busk, Professor Lanchester and Professor L. Prandtl. Sir Richard Glazebrook has been chairman of the Aeronautical Research Committee since its formation as the Advisory Committee for Aeronautics in 1909. He is retiring from the position next month.

AT the fifty-fifth annual general meeting of the Institute of Chemistry, held in London on March 1, the Meldola Medal was presented to Dr. Leslie Ernest Sutton, of Oxford, and the Sir Edward Frankland Medal and Prize to Dr. Leslie Young, of the Royal College of Science. Dr. Jocelyn Field Thorpe, professor of organic chemistry in the Imperial College of Science and Technology, London, was elected president in succession to Dr. G. C. Clayton, director of Imperial Chemical Industries.

DR. WILLIAM BOWIE, chief of the divison of geodesy, U. S. Coast and Geodetic Survey, was reelected honorary president of the Pan-American Institute of Geography and History at the congress held last December in Rio de Janeiro, Brazil.

THE officers of the Harvey Society for 1933–34 are as follows: *President,* Alfred F. Hess; *Vice-president,* R. Keith Cannan; *Treasurer,* T. M. Rivers; *Secretary,* Edgar Stillman; *Council,* S. R. Benedict, Robert F. Loeb and Wade H. Brown.

DR. ARTHUR B. LAMB, president of the American Chemical Society, was the speaker at a luncheon meeting of the writers of abstracts and the assistant editors of *Chemical Abstracts* on March 28. Dr. Charles E. Munroe, who was honorary chairman of the Washington meeting of the American Chemical Society and who has served as an assistant editor of *Chemical Abstracts* since its beginning in 1907, was also a guest of honor.

DR. CHARLES FREDERICK ROOS, formerly assistant professor of mathematics at Cornell University and later permanent secretary of the American Association for the Advancement of Science, has been awarded a Guggenheim fellowship. He plans to write a book on dynamical economics in consultation with European scholars.

DR. A. R. MOORE, research professor of general physiology, University of Oregon, sailed from San Francisco for Japan on March 24, to spend a year as visiting professor of biology in the Tohoku Imperial University at Sendai. He will be in the Biological Institute of the university, the director of which is Professor Shinkishi Hatai. The visiting professorship is maintained by the Rockefeller Foundation.

PROFESSOR J. PROUDMAN has been appointed to the chair of oceanography at the University of Liverpool, vacant through the death of Professor J. Johnstone.

HERBERT L. DAVIS, for the past four years a Heckscher research assistant to Professor W. D. Bancroft at Cornell University, has been appointed assistant professor of chemistry at Westminster College, New Wilmington, Pennsylvania.

DR. CORNELIA T. SNELL has left the Fifth Avenue Hospital to take a position at the College of Physicians and Surgeons of Columbia University. She will work with Drs. T. F. Zucker and Benjamin Berg in connection with their studies of diabetes.

PROFESSOR RALPH J. FOGG, formerly head of the department of civil engineering at Lehigh University, is serving as a technical expert under the National Transportation Committee.

DR. OTTO APPEL, director of the Federal Biological Experiment Station at Berlin, Germany, will visit the Wisconsin potato sections this summer following his visit to the Century of Progress Exposition in Chicago.

DR. R. E. COKER, professor of zoology at the University of North Carolina, who is on leave of absence from the university on the Kenan Foundation during 1932–33, is working at the University of Paris.

A PAPER by Dr. M. A. Tuve and L. R. Hafstad on "Atomic Nuclear Studies at the Department of Ter-

restrial Magnetism," was presented before the Philosophical Society of Washington on March 25.

MR. JOHN RUEL MANNING, in charge of technological investigations, Bureau of Fisheries, Washington, addressed the Alpha Mu chapter of Tri Beta at Western Maryland College on March 21, on "The Nutritional Value of Marine Products."

PROFESSOR JAMES WESTFALL THOMPSON addressed the History of Science Club at the University of California in Berkeley on March 3 on German science in the fourteenth and fifteenth centuries, giving a presentation of the mathematical achievements and the interconnections of Jordanus Nemorarius, Georg Purbach, Regiomontanus and Cardinal Nicholas of Cusa.

THE Bruce-Preller lecture of the Royal Society of Edinburgh will be delivered by Professor C. H. Lander, on October 23. His subject will be "The Utilization of Coal."

A SYMPOSIUM on the utilization of coal, arranged by the British Science Guild, was held on March 27 at the Royal Institution under the chairmanship of Mr. H. T. Tizard. The speakers included Captain B. Acworth, S. Lacey, Eng.-Rear-Admiral W. Scott Hill and A. C. Hardy. The discussion was opened by Dr. O. M. W. Sprague.

DURING February and March the following visitors gave clinics at the Duke Hospital of the Duke University School of Medicine: Dr. Addison G. Brenizer, of Charlotte, on "The Evolution of Thyroidectomy"; Dr. Hugh Trout, of the Jefferson Hospital, Roanoke, on "The Surgical Treatment of Pulmonary Tuberculosis"; Dr. W. W. S. Butler, Jr., of the Jefferson Hospital, Roanoke, on "Transurethral Resection of Prostate"; Dr. Thomas M. Rivers, of the Hospital of the Rockefeller Institute, on "Filterable Viruses in Relation to the Practise of Medicine"; Dr. B. C. Willis, of the Boyce-Willis Clinic, Rocky Mount, North Carolina, on "Perforated Wounds of the Abdomen."

THE fifth lecture to the faculty and students of the School of Medicine, the George Washington University, on the Smith-Reed-Russell Society series was given on March 16 by Dr. Maurice C. Hall, chief of the Zoological Division of the Bureau of Animal Industry, U. S. Department of Agriculture. Dr. Hall's subject was "Drama Anthelmintica." The next lecture in this series, to be given on April 6, by Dr. William H. Howell, chairman of the National Research Council, is entitled "Recollections of a Physiologist during the Past Half Century." The regular faculty seminar for March was given by Professor Charles S. White, of the department of surgery, who spoke on "Chronic Peptic Ulcer in Childhood."

DR. BRONISLAW MALINOWSKI, professor of anthropology in the School of Economics of the University of London, gave a series of lectures on the Messenger Foundation at Cornell University during March on "The Development of Culture: an Enquiry into the Function, Origins and Evolution of Human Beliefs, Customs and Social Organization." The Messenger lectures on the evolution of civilization were inaugurated in 1925, the first lecturer being Professor James H. Breasted, whose subject was the origins of civilization. Other lecturers have been Robert A. Millikan, H. J. C. Grierson, Thomas F. Tout, Edward L. Thorndike, Roscoe Pound, Thomas H. Morgan and Frank Jewett Mather, Jr.

THE Rutgers University chapter of Sigma Xi adopted last year the plan of having monthly lectures, sometimes by members of the university faculty, describing their own research work, and sometimes by visitors. The same plan has been in effect this year, and the complete program is as follows: October, Dr. S. A. Waksman, New Jersey Agricultural Experiment Station, "Humus"; November, Dr. Hugh S. Taylor, Princeton University, "The Concept of Speed in Chemical Reactions"; December, Dr. T. C. Nelson, Rutgers University, "A Comparative Study of the Feeding Mechanism of American and European Oysters"; January, Dr. J. W. Shive, New Jersey Agricultural Experiment Station, "The Rôle of Iron in Plants"; February, Dr. C. G. Abbot, Smithsonian Institution, "The Sun"; March, Dr. T. J. Headlee, Rutgers University, "Some Effects of High Frequency Electrostatic Fields on Insects"; April, Dr. Homer W. Smith, New York University Hospital, "The Physiological Evolution of the Kidney."

PUBLIC lectures to be given on Saturday at 3:30 P. M. at the New York Botanical Garden are as follows: "Spring Wild Flowers," Dr. John Hendley Barnhart, bibliographer and administrative assistant; "Floral and Scenic Features of the Bahamas," Dr. Marshall A. Howe, assistant director; "Minute Marvels of Aquatic Life," Mr. Robert Hagelstein, honorary curator of Myxomycetes; "Sex in the Fungi," Dr. B. O. Dodge, plant pathologist; "Variegated Plants," Dr. A. B. Stout, director of the laboratories; "Floral and Scenic Features of Porto Rico," Dr. H. A. Gleason, head curator; "Travels through the Mountains of Colorado, Wyoming and South Dakota," Dr. Fred J. Seaver, curator; "A Trip to the Philippines," Dr. Elmer D. Merrill, director-in-chief; "Mushrooms," Dr. William S. Thomas, physician.

THE one hundred eighty-fourth regular meeting of the American Physical Society will be held in Washington on April 27, 28 and 29. The Thursday and Friday sessions will be held at the Bureau of Standards and the Saturday sessions at the National Academy

Building. Subsequent meetings are: Salt Lake City, June 15–16, 1933, Pacific Coast; Chicago, June 19–24, 1933, a joint meeting with the American Association for the Advancement of Science; Cincinnati, December 1 and 2, 1933; December, 1933, Pacific Coast, time and place to be announced later; annual meeting, December, 1933, Boston.

THE Canadian Institute of Mining and Metallurgy will meet at Toronto on April 4, 5 and 6. The program calls for some forty addresses by authorities on various phases of mining. For the first time, the Institute of Mining and Metallurgy of London will send its president, Dr. Sydney W. Smith, to confer with the Canadian Association. R. B. Bennett, prime minister, will be the chief speaker at the annual dinner. Other speakers will be Robert C. Stanley, president of the International Nickel Company; Wesley Gordon, federal minister of mines; Charles McCrea, minister of mines for Ontario, and Dr. Smith.

ARRANGEMENTS are being completed for the holding of the 1933 meeting of the Canadian Phytopathological Society at Regina, Saskatchewan, in July. A committee under the chairmanship of Dr. P. M. Simmonds, Saskatoon, has been appointed to look after local arrangements.

THE International Museums Office, on the invitation of the Spanish government, has called a conference to be held in October at Madrid for the study of museum problems.

THOSE interested in forming a Society for Research on Meteorites, whose purpose shall be to promote the discovery, collection, investigation and preservation of meteorites and to advance the science of meteoritics and related sciences through the increase and diffusion of knowledge concerning meteorites, are invited to communicate with the acting secretary of the preliminary organization, Professor H. H. Nininger, director, The Nininger Laboratory, 1955 Fairfax St., Denver, Colorado, or with Frederick C. Leonard, acting president, Department of Astronomy, University of California at Los Angeles, California.

THE following message was sent by President Roosevelt to the fourth congress of the Pan-American Medical Association, which opened at Dallas, Texas, on March 21: "I extend to you and your fellow members of the Pan-American Medical Congress, on behalf of the government, cordial greetings on the opening of the fourth congress, the first to be held in an English-speaking country. The medical profession is deeply interested in the accomplishment of this meeting, which means so much to the health and welfare of the nation, to say nothing of the promotion of friendly relations and mutual understanding between the United States and her sister republics of Latin-America. I am confident that you will find a most hearty welcome by the medical profession and an earnest desire to cooperate with you in every way in furthering the high object of the congress. I wish the members of the fourth congress every success in their great undertaking."

THE Marqués Sanchez Dalp, of Seville, has presented to the Institute of Agrarian Reform his large estates on the banks of the Guadalquivir, covering nearly 10,000 acres and containing 200,000 olive trees and several model farms linked by 56 miles of roads. The Marqués has improved his lands for 40 years and they are now valued at 30,000,000 pesetas (about £700,000). The object of the gift is to help the Spanish government with its schemes of agrarian reform, the intention being that the estates with all the installations on them, such as olive-oil factories and maize and bean sorting and packing machinery, should be used as a school for agriculture.

DISCUSSION

PATENTS ARE ETHICAL

THERE has recently been considerable discussion of the propriety of members of a university faculty taking out patents based on their discoveries. Such comments as I have seen have tended to the view that, if patents are obtained, they should ethically be transferred to the university.

With this view I very decidedly disagree; and my opinion is based, not on theory, but on extensive practical experience.

In the first place very few inventions are financially remunerative. If the university is to take the profit, it should also pay the expenses; and if it did pay the expenses, it would generally have a net loss. If an occasional patent does return more than the fees to the U. S. Patent Office and lawyers, the inventor is not thereby tempted to an enervating luxury. As a member of a university faculty, he generally needs an increase of income over and above his university salary. A good invention is as proper a source of income as the authorship of a good book. If the holder of the patent is freed to some extent from financial stringency and care, he will be the better able to devote himself to further scientific discoveries and useful inventions. Bread, or even a little butter on the bread, for a man and his family is one of the prime requisites for research, although this nutritional feature of productive scholarship is often overlooked.

But there are even better reasons for patenting new ideas whenever possible, and for the discoverer or inventor holding the patent himself. He can push it with more knowledge and energy, and can control it for the general welfare more effectively, than can the financial officers of a university. There is an opinion imputed to Emerson to the effect that the inventor of even a better mouse trap, although he hide in a cabin deep in the forest, will find that the world will beat a wide path to his door. I understand that it is doubtful whether Emerson ever said or wrote anything of the sort. He was a sensible man of considerable experience with new ideas; and certainly this statement is utterly contrary, in the large majority of cases, to actual experience. Inventions, like all other new ideas, have generally to be forced on conservative mankind. It would be easy to point to many inventions and other applications of discovery now saving large numbers of lives that would not yet be in use without advertising and the efforts of salesmen. Without commercialization a large part of all the scientific ideas that are now in constant and active use in our daily lives would be locked in books on the dusty shelves of university libraries. It is properly the business of the creative scholar to see to it that, if possible, his ideas serve mankind in his own generation.

But an even stronger duty rests on a discoverer or inventor. He should see to it that his idea or invention is not misused. He should control it. He should find one or more high-grade concerns to develop it. He should afford them at least such little protection as a patent gives against cut-throat competition, after they have spent money to put the invention into practical form and have made a market for it. Without some assurance of such protection it is difficult to get an idea developed and commercialized. The inventor should so far as possible prevent the sale of inferior or harmful imitations.

Often the investigator or inventor will be unable to accomplish all this. But at least he can do it better than the financial officers of a university. Their responsibilities and duties are sufficiently trying just now without this addition.

In this matter, as in all the other relations of scholars to their universities, it should always be assumed that members of university faculties are men of the highest character. Any new practise, rule or regulation that involves even the smallest imputation to the contrary, or that in any way impairs scholarly freedom, will tend rather to diminish than to insure the maintenance of scholarly ethics and faculty morale. Regulations impair ethics.

YANDELL HENDERSON

YALE UNIVERSITY

UNIVERSITY PATENTS

DR. ALAN GREGG has done a notable service not only to research in medicine but to scientific research in general. John Maynard Keynes has recently said that nothing is more important than that we should get rid of the profit spirit in modern life. His opinion applies more definitely to research than to any other social or human activity. As a matter of history, the scientific discoveries that have ultimately inured to the benefit of society either financially or socially have been made by men like Faraday and Clerk Maxwell who never gave a thought to the possible financial profit of their work. They were driven on by the spirit of curiosity, and that alone should animate workers in scientific laboratories. The moment that research is utilized as a source of profit, its spirit is debased. The state's and the individual's interest in its support is necessarily weakened, and the most glorious characteristic of modern science is debased. There may be a few who will think that Dr. Gregg is treading on their toes. If so, let the "galled jade wince."

ABRAHAM FLEXNER

MATURATION DIVISIONS IN TRADESCANTIA, RHEO AND OENOTHERA

IN a recent communication Dr. Belling,[1] whose sudden and untimely death is a great loss to biology, has made comments on my recent short article in SCIENCE for January 13, 1933 (pp. 49–50). His courteous criticisms seem to turn on the definition of a univalent chromosome. This may conveniently be described as a single (that is not paired with another) chromosome of the first meiotic division. Consequently neither the so-called bivalents nor their constituents can logically be called univalents. According to the results of a number of investigators, in *Tradescantia virginica,* there are found two kinds of chromosome pairs (the so-called synaptic mates), namely, ring pairs, which resemble those generally seen in meiosis in favorable objects, such as Allium, Lilium, etc., and by contrast a varying number of so-called rod pairs. The ring couples are regarded as parasynaptically mated side by side, while the rod bivalents are believed to represent chromosomes paired telosynaptically end to end. We have thus the truly remarkable paradox of the chromosomes of the same species in the identical meiotic division, conducting themselves in fundamentally different fashions. The conception of telosynapsis or end-to-end pairing has long been in growing disrepute, particularly among geneticists. Favorable material seems to show clearly that the meiotic so-called bivalents are primitively always in relation side by side. My extended and somewhat

[1] SCIENCE, 77, p. 260, March 10, 1933.

comprehensive investigations, covering a wide range of both plants and animals, appear to make it clear that the side-by-side pairs are invariably present in the primary meiotic division. *Tradescantia virginica* presents no exception in this respect. Although the profile view of the metaphase seems to show the contrasting ring and rod bivalents, the polar aspect, which appears to have been neglected by other investigators, makes it clear that the two are identical and only represent the face and lateral views of identical structures.

Further, in *T. virginica,* the so-called zygotene or zygonema phase can always be seen at the appropriate stage. Since this stage is properly regarded as the precursor of the side-by-side bivalents (the so-called parasynaptic mates), its presence automatically excludes the possibility of end-to-end pairs of chromosomes (telosynaptic mates). There is thus an additional reason for regarding all the chromosome pairs of *T. virginica* as side-by-side mates and *none* of them as end-to-end mates. Following a sound practise in cytology and transferring these results to the interpretation of the less clear conditions presented by the genus Rheo and certain species of Oenothera, it becomes obvious that the pairs of consecutive homologous segments present in the persistent spireme in these cases in reality represent so-called parasynaptic bivalents, strung out in a longitudinal series. Thus, if we were to arrange the vertically elongated bivalents found at metaphase in Allium or Lilium end to end they would accurately correspond to the strings of chromosomes found in the three genera as discussed in the present connection.

E. C. JEFFREY

LOCAL ELECTRIC ANESTHESIA

IN the issue of SCIENCE for February 24, 1933, is an interesting article, "A Method of Outlining Cutaneous Nerve Areas," by Professor Thompson and Dr. Inman, of the University of California, in which an important use of anesthesia from an alternating current is described and discussed.

During the summer of 1892 I worked with A. E. Kennelly, chief electrician of the Edison Laboratory at Orange (later professor of electrodynamics at Harvard), studying the effects of alternating currents and the huge magnets there upon the human body. Professor Kennelly and I published a paper on "Some Physiological Experiments with Magnets at the Edison Laboratory."[1]

We noted that summer that anesthesia and analgesia could be produced by alternating currents above 2,000 vibrations, though this was not alluded to in the paper mentioned.

[1] *New York Medical Journal,* lxi: 729–732. 1892.

However, in an article[2] of mine in the *American Medical and Surgical Bulletin* appeared the following paragraphs, which I have just copied from the *Bulletin* at the Academy of Medicine Library:

> Several years ago Mr. Kennelly and I experimented at the Edison Laboratory with the sinusoidal current. The results of these experiments have never been made public, for lack of time, until the present moment. We established one singular and interesting fact, which is of therapeutic value, and which I will detail here. The experiments were tried upon Mr. Kennelly, Dr. Charles E. Atwood, one of the assistants at the Vanderbilt Clinic, who kindly aided me, and upon myself. The same results were obtained in each of us. Applying one pole to a nerve trunk, say at the wrist, and another at an indifferent point, there were no perceptible effects as long as the vibrations were below 2000 per second. When we reached that point the parts supplied by the nerve beneath the pole became anaesthetic, so that pricking with a needle or knife, or touching the part, was not perceived. Both the anaesthesia and analgesia were so marked that an incision might have been made without the consciousness of the individual operated upon. The higher the rate of vibration the more noteworthy was this effect. Our apparatus did not permit of our going beyond 3000 vibrations per second. * * * The return of sensibility was instantaneous on interruption of the electric current. Doubtless small operations might be performed by this new method of local anaesthesia. As yet the procedure is in its infancy.

In the autumn of 1892 after this summer work at Orange I asked the surgeons in the surgical department of the Vanderbilt Clinic to be on the lookout for some simple case on which the newly found electric anesthesia could be tested. I was testing it out for various nervous disorders in the Nervous Department of the Vanderbilt Clinic, where I was chief of clinic, with Professor Allen Starr. In a few days Dr. Percy Turnure brought in a young woman with a painful felon of the left forefinger which was exactly suitable for the purpose. The electric anesthesia was quickly produced and Dr. Turnure lanced the finger tip. The operation was apparently painless, though as soon as the current was removed sensation returned, with of course such pain as would be natural after any similar incision.

So far as I know this was the first operation under that type of local anesthesia.

About 1902 Leduc in France began writing articles on electrical anesthesia.

FREDERICK PETERSON

NEW YORK, N. Y.

SELF-STERILITY IN NEMESIA

SEVERAL years ago, working in the greenhouse at Princeton University, I undertook to study the genetic

[2] *Am. Med. and Surg. Bull.* ix: 765–808. 1896.

factors which control flower color in plants of the genus Nemesia. A packet of seeds, labeled "Nemesia —Newton's Glories Mixed," was obtained from Peter Henderson and Co. in New York City, and sixteen plants were raised. Comparison with the description of this genus in the Flora Capensis seemed to indicate that these plants belonged to the species *N. strumosa.*

It was desired to obtain seed from self-pollinations for the next generation, but every flower which was selfed set no seed whatever, and as many as fifteen flowers were pollinated on some plants. Some crosses between these plants, made at the same time as the selfings, were fertile, proving that both the pollen and ovules were functional and that the failure to set seed was due to physiological incompatibility, commonly called self-sterility. Two families studied in the succeeding generation gave the same results, although few intra-family crosses were made.

In the third generation, three families were studied more intensively. In one, ten plants were selfed and all proved self-sterile, although one plant exhibited a slight tendency to be pseudo-fertile. Seventy-four of the ninety possible crosses were made and showed that two and only two intra-sterile, inter-fertile groups were present, of which one consisted of seven and the other of three plants. Ten plants of a second family were completely self-sterile when as many as ten flowers on a plant were self-pollinated. Fifty-nine crosses were made within this family and again two groups were found to be present. All crosses behaved regularly. In the third family, six plants belonged to one intra-sterile, inter-fertile class and six to another and all twelve were self-sterile. Only one cross exhibited behavior not in accordance with the general trend. Inter-family crosses between the two latter families showed that no group was common to both. A similar result was noted for the first and third families but, unfortunately, I did not cross the first two.

This study is being continued this year to learn whether Nemesia behaves like Nicotiana and most other plants which have been studied with respect to self-sterility.

HERBERT PARKES RILEY

BUSSEY INSTITUTION
HARVARD UNIVERSITY

A NEW VASCULAR FUSARIUM DISEASE OF PEAS

DURING the course of an investigation of pea diseases, particularly of Fusarium wilt, carried on under the direction of Dr. J. C. Walker, of the Department of Plant Pathology, University of Wisconsin, a wilt disease possessing many of the characteristic symptoms of Fusarium wilt, caused by *F. orthoceras* v. *pisi* but produced by another species of Fusarium, has been repeatedly separated from the pea disease complex. This disease was first seen in Wisconsin in 1931, and was encountered frequently and found to be wide-spread in Wisconsin, Maryland and Delaware during the 1932 season. Specimens were also received from New Hampshire, Massachusetts, Idaho and Montana.

The new disease is tentatively referred to as "near-wilt" because of its close resemblance to the wilt disease previously described by Linford.[1] As they occur in the field and upon plants grown in artificially infested soil, the symptoms of the two diseases are so similar that it is practically impossible to differentiate them by this means. Typically the foliage takes on a yellowish cast, the leaflets and stipules become recurved and the stunted plant dies prematurely. Usually the vascular elements become brightly stained an orange or reddish color some distance up the stem.

One of the significant features of the new disease is that it occurs upon varieties known to be 100 per cent. resistant to *F. orthoceras* v. *pisi.* This is of great importance to both growers and seedsmen, for it means that certain seed stocks sold as resistant to the wilt caused by *F. orthoceras* v. *pisi* may wilt in the field because of another fungus.

Satisfactory diagnoses of these two diseases can only be made by culturing the causal fungi. The purple pigmentation of the near-wilt Fusarium upon certain media is useful in distinguishing it from the wilt pathogen. Although there is a wide range of pigmentation exhibited by the various strains of *F. orthoceras* v. *pisi* this purple type seldom is approached. An additional aid in distinguishing them is the abundance of spores, including macroconidia, produced by the near-wilt Fusarium, inasmuch as *F. orthoceras* v. *pisi* produces but few spores in culture and these few are microconidia, with infrequent exceptions.

The new disease may be distinguished from Fusarium rootrot, caused by *F. martii* v. *pisi,* since in rootrot a cortical decay of the underground stem conspicuously precedes the invasion of the stele, while both near-wilt and wilt are primarily diseases of the xylem tissue and not of the cortex. Under field conditions diseased plants frequently show both cortical and vascular invasion, and culturing must be used to identify the fungi present. *F. martii* v. *pisi* is easily distinguished in culture from the two vascular Fusaria by its masses of blue green spores.

WILLIAM C. SNYDER

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[1] M. B. Linford, "A Fusarium Wilt of Pea in Wisconsin," Wis. Agr. Exp. Sta. Res. Bul. 85, 44 pp. illus. 1928.

SPECIAL CORRESPONDENCE

THE ELLA SACHS PLOTZ FOUNDATION FOR THE ADVANCEMENT OF SCIENTIFIC INVESTIGATION

DURING the ninth year of the Ella Sachs Plotz Foundation for the Advancement of Scientific Investigation, ninety applications for grants were received by the trustees, sixty-five of which came from sixteen different countries in Europe, Asia, South and North America and Australia, the remaining twenty-five coming from the United States. The total number of grants made during this year was thirty-three, one of these being a continued annual grant. Eighteen of the new grants were made to scientists in countries outside of the United States.

In the nine years of its existence the foundation has made 179 grants, and investigators have been aided in Argentina, Austria, Belgium, Chile, China, Czechoslovakia, Esthonia, Estland, France, Germany, Great Britain, Hungary, Italy, Latvia, Netherlands, Palestine, Poland, Portugal, South Africa, Sweden, Switzerland, Syria and the United States.

The list of investigators and the purpose of their researches aided in the current year is as follows:

Dr. Z. M. Bacq, Brussels, Belgium, $300 for research on problems in relation to the physiology of the sympathetic nervous system.

Dr. E. T. Bell, University of Minnesota, $500 for continuation of kidney studies.

Dr. R. Bossert, Munich, Germany, $400 for continuation of work on cholesterol-ergosterol metabolism.

Dr. Henry Chabanier, Paris, France, $400 for researches to determine the iso-electric points of blood proteins and to do ultrafiltrations of blood.

Professor Robert Chambers, New York University, $500 for work on problems in kidney secretion.

Professor Alfred Chanutin, University of Virginia, $300 for chemical analysis of blood and tissues in his partially nephrectomized rats fed on a variety of diets.

Dr. Erwin Chargaff, Berlin, Germany, $400 for investigations dealing with the chemistry of pathogenic bacteria, especially lipoids and carbohydrates of acid-fast group and of diphtheria bacteria.

Professor Dr. Herbert Elias, Vienna, Austria, $200 for continuation of investigations on the globulin and albumin contents in sera of patients with nervous diseases.

Professor Dr. Philipp Ellinger, Düsseldorf, Germany, $300 for continuation of work on physiology, pathology and pharmacology of the kidney.

Professor Boris Ephrussi, Paris, France, $400 for a new method for the measurement of respiratory exchanges in tissue-culture cells.

Dr. Emil Epstein, Vienna, Austria, $300 for study of the Neiman-Pick disease and amaurotic idiocy and the lipoids of the brain.

Dr. G. Favilli, Florence, Italy, $300 for continuation of research on the relation between undulant fever and epizootic abortion.

Professor Dr. Alfred Fleisch, Tartu-Dorpat, Estland, $200 for investigations concerning the adequate stimulus for dilatation of the arterioles during work.

Professor E. Gellhorn, University of Oregon, $300 for continuation of work on the influence of internal secretions on permeability.

Dr. R. W. Gerard, University of Chicago, $300 for work on the chemical and physical changes in nervous tissue during rest and activity.

Dr. David Glusker, Jewish Hospital of Brooklyn, $400 for study of blood lipids in children.

Professor Allen D. Keller, University of Alabama, $250 for continuation of research on brain-stem function.

Dr. Walter P. Kennedy, Edinburgh, Scotland, $300 for investigation on "The Reproductive Endocrine Balance in the Human Female."

Dr. Th. Konschegg, Graz, Austria, $400 for research on the relationship of the glandula suprarenals, adrenalin and blood pressure.

Dr. H. A. Krebs, Freiburg, Germany, $350 for continuation of studies on the breakdown of protein in animals and on the metabolism involved in the action of insulin.

Professor William deB. MacNider, University of North Carolina, $175 for work on nephritis.

Dr. F. Mainzer, Rostock, Germany, $300 for studies of excreted albumin to clear up the physico-chemical forerunners of albuminuria.

Dr. David Marine, Montefiore Hospital, New York City, $300 for continuation of an attempt to separate the powerful goitrogenic agent present in cabbage.

Professor C. A. Mills, University of Cincinnati, $200 for continuation of metabolic experiments.

Professor H. O. Mosenthal, New York Post-Graduate School, $350 for research on the result of continuous infusions of small doses of adrenalin on kidney, blood pressure, and peripheral blood vessels as measured by temperature.

Dr. Louis A. Rapkine, Paris, France, $350 for research on cell division.

Dr. William T. Salter, Huntington Memorial Hospital, Boston, $500 for work on the metabolic changes in animals, particularly with regard to the enzymes concerned with protein metabolism and with oxidation.

Dr. Gordon H. Scott, Washington University School of Medicine, St. Louis, $300 for study of the mineral constituents of the walls of the blood vessels.

Dr. E. A. Spiegel, Temple University, $300 for continuation of experiments on epilepsy and on the vegetative nervous system.

Thorndike Memorial Laboratory, Boston City Hospital (Prof. George R. Minot, Director), $500 a year (continued since 1927) in recognition of Dr. Francis W. Peabody's services.

Dr. C. Van Caulaert, Strasbourg, France, $400 for biological work on nephritis.

Professor René Wurmser, Paris, France, $500 for continuation of studies of oxidation-reduction phenomena in cells.

Professor Edgard Zunz, Brussels, Belgium, $100 for studies of pancreatic secretion.

Applications for grants to be held during the year 1933–1934 should be in the hands of the executive committee before May 1, 1933. They should be sent to Dr. Joseph C. Aub, Collis P. Huntington Memorial Hospital, 695 Huntington Avenue, Boston, Massachusetts.

SOCIETIES AND MEETINGS

THE COLORADO-WYOMING ACADEMY OF SCIENCE

THE sixth annual meeting of the Colorado-Wyoming Academy of Science was held on November 25 and 26, 1932, at the Colorado Agricultural College, Fort Collins.

Friday and Saturday mornings were given over to the reading of papers in section meetings. One hundred thirty-six papers were presented, These were distributed as follows: Chemistry, 12; education, 13; geology and geography, 10; physics, 15; plant science, 25; psychology, 16; social science, 16, and zoology 29.

About 175 members were present. The attendance of the public and college students was unusually large.

A new feature of the program was the display of exhibits of the scientific work carried on by members of the academy. Sixty exhibits were presented. These included teaching devices, demonstrations of collections of animals and plants, rare scientific books, chemical and physical apparatus, experiments in physics and chemistry, cooking devices, historical manuscripts, charts for psychology and education, experiments in hydraulics, plant breeding, plant pathology, models of ecological situations, etc. These were on display during the entire session. The enthusiastic interest shown by academy members, students and the visiting public insured the continuance of this feature.

At the academy dinner on Friday evening, A. S. Adams, of the Colorado School of Mines, spoke on "A Defense of Mass Production."

The following officers were elected: *President:* F. C. Jean, Colorado State Teachers College; *Vice-President:* S. H. Knight, University of Wyoming; *Secretary:* R. J. Gilmore, Colorado College; *Treasurer:* O. M. Dickerson, Colorado State Teachers College.

C. H. Hutchinson, University of Colorado, was appointed chairman of the program and publications committee.

F. E. E. Germann, University of Colorado, was appointed representative to the conference of state academies.

Members of the executive committee are: O. A. Beath, University of Wyoming; F. F. Coen, Colorado Agricultural College; F. F. Ramaley, University of Colorado; A. S. Adams, Colorado School of Mines; T. R. Garth, University of Denver; F. P. Goeder, Colorado Agricultural College; R. G. Gustavson, University of Denver.

The 1933 meeting will be held at the University of Wyoming, Laramie, on December 1 and 2, 1933.

R. J. GILMORE,
Secretary

THE ALABAMA ACADEMY OF SCIENCE

THE tenth annual meeting of the Alabama Academy of Science was held at Birmingham-Southern College, Birmingham, Alabama, on March 10 and 11. The attendance was better than at any previous meeting.

The presiding officer was Professor J. F. Duggar, Alabama Polytechnic Institute. There were two general sessions and sectional meetings were held by the following sections: biology, chemistry, physics and mathematics, industry and medicine. A fifth section was organized at the meeting, which will cover the following subjects: anthropology, archeology and geology.

The internal organization of the academy was changed at this meeting. The plan adopted is in some respects similar to that of the American Association for the Advancement of Science; that is, sectional chairmen are automatically vice-presidents of the academy. The offices of first vice-president and second vice-president were discontinued.

The officers elected for 1933–34 are as follows:

President: James L. Brakefield, Howard College, Birmingham, Alabama.

General Secretary: W. A. Whiting, Birmingham-Southern College, Alabama.

Treasurer: A. G. Overton, Alabama By-Products Corporation, Tarrant.

Councilor to the American Association for the Advancement of Science: Emmett B. Carmichael, University of Alabama.

Editor of the Journal: E. V. Jones, Birmingham-Southern College.

The following were elected as chairmen and secretaries of the various sections:

Anthropology, Archeology and Geology:

Chairman: R. S. Poor, Birmingham-Southern College.
Secretary: G. Andrews, University of Alabama.

Biology:

Chairman: Septima Smith, University of Alabama.
Secretary: Thera Towery, Howard College.

Chemistry, Physics and Mathematics:

Chairman: Roger W. Allen, Alabama Polytechnic Institute.
Secretary: W. N. Arnquist, Alabama Polytechnic Institute.

Industry:

Chairman: E. A. Hawk, Birmingham, Alabama.
Secretary: T. N. McVay, University of Alabama.

Medicine:

Chairman: Franklin S. DuBois, University of Alabama.
Secretary: G. D. Matthews, Birmingham.

Representatives from eleven high schools met with the academy on Saturday morning, March 11, and organized the Junior Academy of Science of Alabama. Each high school had one exhibit and one member to give a paper. There were more than a hundred in attendance at the high school program. Officers of the Junior Academy are:

President: Winthrop R. Hubler, Ensley High School.
Vice-president: R. E. Chambers, Woodlawn High School.
Secretary: Martha Bray, Ramsay Technical High School.

EMMETT B. CARMICHAEL,
Vice-president of the Academy Conference

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AMMONIATION OF PEAT FOR FERTILIZERS

FOR several years much of the higher grade organic fertilizer materials, such as cottonseed meal and animal tankage, has been diverted into feedstuffs. To use such material in fertilizer mixtures it was necessary to compete with their valuation on a protein basis in feeds. Under such competition the price paid for nitrogen of this sort was considerably greater than nitrogen contained in inorganic fertilizer materials. While in the last few years the price differential has not been so great, due to the low price of feeds from grain products, it still exists and the demand for organic nitrogenous materials in fertilizers has held this price higher than that of the inorganic materials. The desirability of utilizing some abundant organic substance as a carrier of the cheap nitrogen derived from synthetic ammonia led to the investigation by the Fixed Nitrogen Research Laboratory of peat as a possibility in this direction. It is well known that peat occurs in large quantities and in commercially workable beds at widely distributed points throughout the eastern part of the United States. Such deposits may be found from Minnesota to Maine, from Maine to Florida, and along the coast of the Gulf of Mexico.

Experiments have been carried out by the authors to utilize peat as a nitrogen carrier by treating the air-dried material with anhydrous ammonia. Four types of peat have been used and the conditions of treatment have been varied to study the effect of time of treatment, concentration of ammonia and temperature. A quantity of the ground peat passing a 14-mesh screen was loaded into a steel bomb and anhydrous ammonia added in excess. The closed bomb was placed in an electric oven at the temperature under which the experiment was carried out. The temperature used varied from room temperature to 300° and the pressure developed was that obtained under conditions necessary to retain the ammonia in the bomb varying from 100 to 300 atmospheres. The four types of peat investigated yielded products of a nitrogen content of 4 to 6 per cent. at 50°, 10.5 to 13 per cent. at 180°, and 14 to 21 per cent. at 300° C. It was found that treatment after 20 hours had very little effect in adding more nitrogen. Increasing amounts of moisture tended to lower the content of nitrogen in the product, but did not decrease it very sharply. From these results it appears that the temperature variation affects the amount of nitrogen more than any of the other conditions and that by controlling the temperature and water content of the material practically any nitrogen content up to 20 per cent. is obtainable, depending somewhat upon the character of the peat used.

The original peats contained from 1 to 3 per cent. of nitrogen, which is very slowly available as plant food, but under the conditions of treatment here described, this nitrogen becomes a part of the total nitrogen, practically all of which is available according to chemical tests. Analyses have shown that the nitrogen contained in the ammoniated peat is partly water-soluble and partly water-insoluble, although the water-insoluble part is roughly about two thirds of the total. The ammoniated material is considerably darker than the untreated peat, ranging from dark brown to almost black in color. It is slightly more dense than the original peat and decidedly more easily wetted on coming in contact with water.

The product is of such physical condition as to be well suited for use as a conditioner in mixed fertilizer or for direct application. It promises to be of great importance in offering a cheap nitrogen carrier which, used in mixed fertilizer, will prevent caking of the mixture and keep it in condition suitable for easy distribution. The condition of the nitrogen being partly water-soluble and partly water-insoluble makes it of essential value where danger of leaching or loss through drainage is encountered. Substitution of this material for part of the inorganic materials in the fertilizer mixtures will also be of value in diminishing the burning effect of highly concentrated mixtures, as the amount of water-soluble nitrogen would be reduced thereby.

The advantages of ammoniated peat from the standpoint of fertilizer use are numerous and apparently convincing, and in addition both peat and ammonia from which it is made are cheap and abundant. There are estimated to be 14 billion tons of peat covering 110 million acres in the United States, and ammonia as produced from nitrogen fixation processes is one of the cheapest forms of nitrogen. While the process of manufacture has not yet been worked out, indications are that it will be relatively simple and cheap. Investigations on the details of the technical problems involved are being actively prosecuted.

In the soils unit of this bureau, H. G. Byers and I. C. Fenstal, while engaged on a study of the decomposition of peat, on heating it with aqueous ammonia in a closed vessel obtained a peat product with an increased nitrogen content.

R. O. E. DAVIS,
WALTER SCHOLL

BUREAU OF CHEMISTRY AND SOILS
U. S. DEPARTMENT OF AGRICULTURE

AN ACCURATE METHOD FOR MEASURING NEW-BORN MICE

WHILE carrying on growth studies of the mice of the genus *Peromyscus,* it became necessary to devise some method for the accurate measurement of newborn and very young mice. For the first two or three days after birth, these mice are so small, squirmy and curled in posture that it is almost impossible to take accurate measurements of the total length, tail length and hind foot by the usual hand methods.

The idea was therefore conceived of taking pictures of each litter with a Leica camera. A metric scale was pictured at the same exposure so that the mice were all taken at a fourth natural size. The negatives were then projected upon a screen by means of an ordinary lantern slide projector at forty times the negative size or ten times natural size. The measurements were then taken from the screen picture and divided by ten. The curved areas, such as the total length, were measured with a pair of dividers. The cost per picture is nominal where a Leica camera and a projecting apparatus are available, and the accuracy of this method fully compensates for the small amount of time and labor involved. It is suggested that this method may also prove efficient in measuring other small animals.

ARTHUR SVIHLA

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A NEW SOURCE OF WORKING CURRENT FOR POTENTIOMETERS

THE writer has observed that a two-volt primary battery on the market, known as an "air-cell" battery,[1] has characteristics which make it an almost ideal source of working current for a potentiometer.

This battery has a rated capacity of 600 ampere hours and a flat voltage discharge curve if the current drain does not exceed the specified 650 milliamperes. This is ample capacity for a potentiometer for many months' use.

The writer has used such a battery in place of a storage battery and has found that when protected against changes of temperature the working current will remain constant for hours and in some cases an entire working day without adjustment.

The above features, together with its cheapness and continuity of service, make it a very desirable source of current. The potential of a storage battery drops steadily until it reaches a point where it must be replaced and recharged.

LESTER F. BOSS

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WOODS HOLE, MASS.

SPECIAL ARTICLES

THE EFFECT OF GALACTOSE FEEDING UPON DEPANCREATIZED DOGS

THE studies of Roe and Schwartzman,[1] in which it was shown that diabetic subjects have practically as good a tolerance for galactose as normal subjects, suggested that it would be of interest to study the influence of pancreatectomy upon the metabolism of galactose. We have therefore undertaken an investigation of the metabolism of galactose in depancreatized dogs,

[1] J. H. Roe and A. S. Schwartzban, *Jour. Biol. Chem.*, 96: 717, 1932.

[1] Eveready Air-Cell "A" Battery, manufactured by the National Carbon Company.

and wish to make a brief preliminary report at this time.

Dogs were placed in metabolism cages and water was allowed *ad libitum*. Twenty-four hour samples of urine were collected under toluene. The principal chemical data obtained were determinations of the fasting blood sugar and of the amounts of galactose, glucose and nitrogen of the urine, and the D:N ratio. After obtaining control data the dogs were totally depancreatized under ether anesthesia. Our usual procedure was to determine the D:N ratio of the urine upon the second and sometimes third days after pancreatectomy under fasting conditions, and the dogs were then fed galactose in water in amounts varying from 1 to 6 grams per kilo per day for periods varying from 4 to 9 days. During the period of galactose feeding the amounts of galactose, glucose and nitrogen in the 24-hour samples of urine were determined and the D:N ratio was calculated. The fasting blood sugar was also determined each day upon samples of blood collected in the morning before galactose was fed. Following these studies the surviving animals were given food mixed with galactose, and observations, together with irregular chemical studies, were made until the animals died.

In control studies the dogs were found to excrete in the urine 17 to 30 per cent. of the ingested galactose. Following pancreatectomy the urinary excretion increased to quantities ranging from 32 to 57 per cent. of the ingested galactose.

After pancreatectomy the D:N ratio of the urine during galactose feeding either kept at essentially the same value as obtained in the control studies before galactose feeding or in some cases decreased considerably. This finding shows that the galactose was not converted into glucose by the depancreatized animals, and since only 32 to 57 per cent. of the ingested galactose was excreted in the urine, the evidence indicates that about one half of the galactose fed to the depancreatized dogs was retained in their tissues and apparently was utilized.

TABLE I

COMPARISON OF GALACTOSE AND GLUCOSE TOLERANCE OF DEPANCREATIZED DOGS

Dog	Days after Pancreatectomy	Feeding	24-Hour Urine			
			Galactose Gms.	Glucose Gms.	Nitrogen Gms.	D:N
1	21	18 gm. galactose	8.84	4.69	2.43	1.9
	22	18 gm. glucose	.....	17.50	2.26	7.7
2	7	18 gm. galactose	7.29	7.28	2.95	2.4
	8	18 gm. glucose	.....	15.35	1.89	8.1
3	8	30 gm. glucose	.....	26.23	4.56	5.8
	9	30 gm. galactose	9.95	15.16	4.30	3.5
4	6	32 gm. galactose	13.20	10.58	3.21	3.3
	7	32 gm. glucose	.....	27.60	2.96	9.3
	8	32 gm. galactose	13.44	5.41	2.11	2.5
5	8	21 gm. galactose	7.25	4.00	.....	.....
	9	21 gm. glucose	.....	15.50	.....	.....

In Table I are shown comparative studies of galactose and glucose feeding to depancreatized dogs upon consecutive days. When glucose was fed there was a much greater excretion of glucose in the urine than when galactose was fed and the D:N ratio was approximately 2 to 4 times as great. Even if one totals the amounts of galactose and glucose that were excreted in the 24-hour period of galactose feeding (a procedure that is unwarranted because the normal dog excretes galactose in the urine) it will be found that there was less total sugar excreted upon galactose feeding than upon glucose feeding. These data show that there is a preferential utilization of galactose as compared with glucose by the depancreatized dog.

The fasting blood sugar of 5 depancreatized dogs ranged from 221 to 350 mg per cent. during the period when galactose only was fed. While receiving galactose the fasting blood sugar of one dog increased from 261 to 304 mg per cent. and that of the others either remained at essentially the same level or diminished, the greatest decrease being from 350 to 252 mg per cent. in 3 days of galactose feeding.

By galactose feeding we were able to prevent or suppress some of the sequelae of pancreatectomy. Vomiting was either suppressed or prevented in the dogs receiving galactose by mouth or intravenously. Apparently there is no other conclusion than that the galactose was responsible for this favorable result. As a result of the prevention of vomiting, the dogs were able to take water and did not become dehydrated. Ketone body formation and acidosis developed in our animals, but most of them survived the acute period of ketonuria, during which galactose only was administered in some instances, while in other instances sodium bicarbonate was administered in addition to galactose.

The survival periods of the depancreatized dogs, which did not receive insulin and to which we administered galactose, are as follows: One dog lived 5 days; 2 dogs 6 days; 1 dog 7 days; 1 dog 12 days; 1 dog 14 days; 1 dog 19 days; 1 dog 30 days; and 1 dog was sacrificed 41 days after pancreatectomy. There is no record in the literature of survival periods of totally depancreatized dogs not receiving insulin

through the post-operative period that are as long as some of those obtained by us with galactose feeding.

The influence of galactose feeding with respect to healing of the dog's operative wound is apparently of significance. It is very well known that the abdominal incision of the depancreatized dog becomes infected and does not heal. We obtained complete healing of the mid-line incision of the dogs which lived 30 and 41 days, and in the other dogs, which lived 10 days or more, there was more or less healing. Apparently there is no other conclusion than that galactose feeding had some influence in bringing about these favorable results.

Grateful appreciation is expressed to Smith, Kline, and French, Inc., Philadelphia, Pa., for donations of galactose.

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THE INCIDENCE OF COLOR BLINDNESS AMONG RACES[1]

IN SCIENCE in 1930,[2] the writer announced the beginning of an experimental study of the incidence of color blindness among Indians. Since then there have been, under his direction, expeditions to test various races in America by trained investigators, *i.e.*, four expeditions to test Indians—at Santa Fé and Albuquerque, New Mexico; Holy Rosary and St. Francis Missions in South Dakota; Haskell Institute at Lawrence, Kansas; in Colorado and New Mexico at various points, where we tested Utes, Apaches and Navajo; three expeditions to test Mexicans, the native-born (Spanish-Americans) and another to test immigrant Mexicans in Colorado, and still another to test the natives of Old Mexico in Mexico City; three expeditions to test Negroes, one in Tennessee, one in North Carolina and still another in Colorado. The unselected whites and Jews were tested in and around Denver.

The first three Indian expeditions were made possible by a joint grant between the National Research Council and the University of Denver. All the other expeditions were financed by the university.

The test used in the present investigation was the Ishihara Color Blindness Test, which has been used rather extensively in this country, particularly by Miles, Haupt and Clement. Our procedure was to test one eye at a time, but followed the general directions of the author of the test. By means of automobile goggles, with the glasses punched out and exchangeable blinds, one eye was tested at a time. It should be said that no case of monocular color blindness was discovered by the investigator. No case of total blindness was brought to light; consequently these results are for complete and incomplete red-green blindness. With results from the same test Miles[3] has reported for various groups of white males

[1] Paper read before the Colorado-Wyoming Academy of Sciences on November 25, 1932.

[2] T. R. Garth, "The Color Blindness of Indians," SCIENCE, 71: 468, 1930.

[3] W. R. Miles, "One Hundred Cases Color Blindness

TABLE I

THE INCIDENCE OF COLOR-BLINDNESS AMONG RACES OBTAINED WITH THE ISHIHARA COLOR-BLINDNESS TEST BY GARTH *et al.*

Racial group	Males			Females		
	Number tested	Color-Blind		Number tested	Color-Blind	
		No.	Per cent.		No.	Per cent.
Whites, unselected	795	67	8.4	232	3	1.3
" Jews	200	8	4.0	175	0	0
Indians, F. B. var. tribes	562	14	2.5	337	0	0
" " " Navajo	535	6	1.1	456	3	0.7
" mixed bloods	480	25	5.2	523	4	0.8
Mexicans, Old Mexico	571	13	2.3	494	3	0.6
" immigrants	523	13	2.5	469	4	0.9
Spanish-Americans	346	13	3.8	390	3	0.8
Negroes, Southern	538	21	3.9	496	4	0.8
" Northern	254	7	2.8	165	0	0

an average incidence of 8.2 per cent. and around 1 per cent. for white females; Haupt's report[4] indicates incidence of 7.8 per cent. for white males; and Clement[5] certain incidences given below for Indians, full bloods, mixed bloods of the southwest, and northern Negroes of Connecticut. His Indians numbered 392 full bloods, 232 mixed bloods, his Negroes 323.

The Indians of the present study represent practically the whole of the United States—for instance, one mixed blood from New York City, seven full bloods from North Carolina, seven from California. The various Indian tribes are well represented, though most of the Indians are Pueblos, Navajos and Sioux.

In Table I is given a preliminary report of the results of the investigation to determine the incidence of color blindness among races with the Ishihara test. It is our intention to continue carrying on the investigation, particularly in America and in the countries of Turkey and India.

Upon examination of Table I, it will be seen that the result of testing unselected whites in Colorado agrees well with results gotten by Miles in California and Haupt in Baltimore, *i.e.*, for white males an incidence of about 8.0 per cent. and females 1.0 per cent. Full-blood Indians and Negroes agree fairly well with results gotten by Clement, but our percentage results for mixed-blood Indians do not agree with Clement's results. He obtained for full bloods 2.0 per cent.—mixed bloods 1.2 per cent., and Negroes 3.4 per cent. The Navajos tested by us show a great departure from Indians of other tribes, since they have for males an incidence of 1.1 per cent. This is the first report of testing Mexicans with any color blindness test, though it is not the first time they have been tested. Information has come direct to the author of the testing by Dr. Luis Serrano with the *Mosaics Serrano*—a test derived from the Stilling test—of an incidence of 2.3 per cent. for males and 0.0 per cent for females, the numbers tested being respectively 609 and 415.

It will be seen upon examining Table I that according to the Ishihara test unselected white males are afflicted with the defect of color blindness more than any one of the others of the racial groups. In fact, when we treat the data with a view to determining whether or not the differences in the proportions are real, we find they are so between unselected white males and the males of any of the other racial groups, full-blood Indians, Negroes and Mexicans, excepting in the case of the mixed-blood Indians, with an approximation to a difference (2:75) in the case of the Jews. When a real difference between the percentages is indicated $D/\sigma_{diff.}$ should be 3 and more.[6] We may say, then, that a real difference or a close approximation to it is indicated between unselected whites and the other racial groups here represented, excepting the mixed-blood Indians, and even between them and Mexicans.

As to differences in percentages between the remaining groups, these are not indicated, excepting in the case of full-blood Navajos and the mixed-blood Indians, where there is a close approximation to difference (the figure is 2.9), between Navajos and Southern Negroes. It is interesting to note that neither the Jewish groups, the Mexican groups, the Negro groups nor the full-blood Indian groups differ among themselves when classified geographically, nor do they differ when classified superficially racially with the exception mentioned, Navajos and Southern Negroes.

The investigator is not disposed to call the indicated differences racial differences, since they do not hold to racial lines, but he is disposed to think they may be due to some selective factor.

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